Adaptation and acclimation of leaf traits to environmental change in time and space

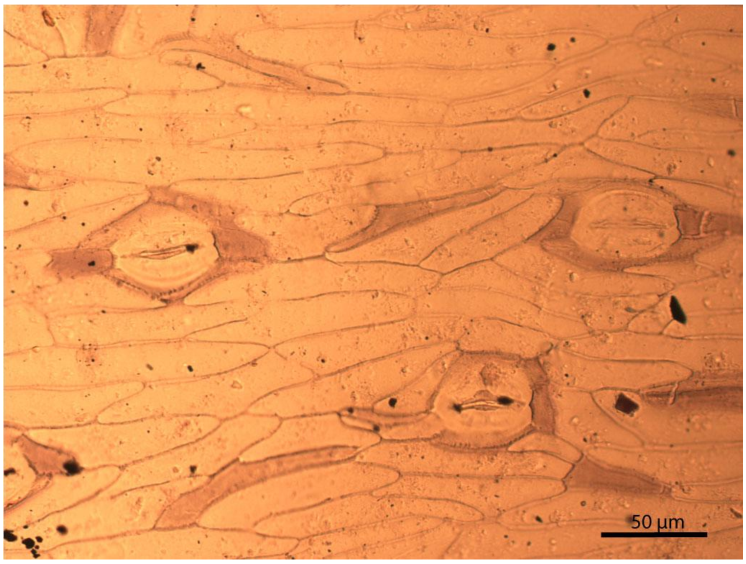

Image by Kathryn Hill; *Bowenia johnsonii* stomatal image, pinnule cuticle courtesy of Greg Jordan.

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Abstract

Stomatal responses to environmental and climate changes have been widely investigated. However, stomatal response to these factors is not predictable. Factors that affect stomatal morphology vary depending on the type of plant, the environment to which it has adapted, or acclimated within, and climate changes on both the long and short term scales. Stomatal morphology controls important aspects of the physiological functioning of a plant, particularly photosynthesis and water loss and therefore stomatal change influences photosynthetic and transpirational potential.

This research examines changes in stomatal anatomy in response to climatic and environmental factors using Australian species. These changes have been investigated on both long term and short-term responses that are adaptation and acclimation, respectively. Stomatal density and size have been measured, and leaf width or area. Maximum potential water loss through open stomata, g_{wmax} (mol m^{-2} s^{-1}), have also been calculated using the stomatal measurements. The response of these traits to the environmental clines of elevation and latitude are shown; these environmental clines were concurrent with the climatic clines of temperature and rainfall. Herbarium, sub-fossil and fossil specimens are used to investigate responses to CO_2.

Responses to climatic clines are shown for all species though these responses were varied. There is a positive relationship between g_{wmax} and temperature for two different angiosperm species, *Dodonaea viscosa* subsp. *angustissima* and *Melaleuca lanceolata* that suggests that the species are increasing the potential for evaporative leaf cooling when temperatures are high. There is also a stomatal

response to rainfall of a littoral Queensland angiosperm *Melaleuca quinquenervia*. This response was weak across the short, 12 year time frame tested. In contrast, stomata measured across a 7300 year time frame, that was available from a continuous data set from Swallow Lagoon on Stradbroke Island in Queensland, showed no relationship between stomatal traits and rainfall. There was also no response to CO_2 in either the short term or long term dataset. This species has been deemed unsuitable for use as a rainfall proxy in Queensland during the past 7300 years. The final data chapter shows the response of pinnules of the cycad *Bowenia* to CO_2 with pinnule ages varying from 65Ma to present. This response was found to be inconsistent, with no response in the extant species, but a negative relationship between stomatal density and CO_2 across the Eocene to the present day. This is similar to what has been reported by others researching cycads thus we conclude that environmental change can force change in cycad stomata.

This thesis shows that stomata are capable of acclimating and adapting to different environmental and climatic clines across space and time, but that the responses vary with species.

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